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Most northern Oriental distribution of *Zethus* Fabricius (Hymenoptera, Vespidae, Eumeninae), with a new species from China

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Abstract

The distribution of *Zethus* Fabicius, 1804, in the Oriental and Palaearctic regions is discussed, with special reference to the northeastern Oriental species. A newly discovered species, *Z. velamellatus* Tan, **sp. n.** from China (Zhejiang), is described and illustrated. The first key to species of *Zethus* Fabricius from China is presented. *Zethus nigerrimus* Gusenleitner, 2001 is recorded for the first time from China and redescribed.

Keywords

Zethus, China, key, new record, new species

Introduction

Zethus Fabricius, 1804, is the largest eumenine genus with 272 valid species of which the majority (230 spp.) occurs in the New World (Carpenter 2011, Lopes et al. 2015, 2017, Cooper 2016, Nguyen and Carpenter 2016, Nguyen and Xu 2017, Selis 2017, Yeh and Lu 2017). The genus is characterized by having propodeum with orifice elongate, acutely pointed dorsally, propodeal valvula elongate and quadrate, separate from propodeal lamella; labial palp four-segmented; mid-tibia usually with two spurs (Bohart and Stange 1965, Nguyen and Carpenter 2016, Tan et al. 2018, submitted).

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Although they are widespread in the tropics, with 25 species occurring in the Oriental Region (Nguyen and Carpenter 2016, Nguyen and Xu 2017, Yeh and Lu 2017), only few species and specimens are known from China. Lee (1985) was the first to record a *Zethus* sp. from China: *Z. dolosus* Bingham, 1897. Unfortunately, the record by Lee (1985) was overlooked by Zhou et al. (2011) and Nguyen and Xu (2017). Up to the present, there are only four species recorded from China (Lee 1985, Nguyen and Xu 2017, Yeh and Lu 2017, Tan et al. 2018, submitted). In this paper, two additional species, *Z. velamellatus* Tan, sp. n. and *Z. nigerrimus* Gusenleitner, 2001, rec. n., are added to the Chinese fauna. A key to species of the genus *Zethus* from China is included.

Material and methods

Specimens were collected by hand net. The studied specimens are deposited in the Hymenoptera Collection of the College of Life Sciences, Northwest University, Xi'an (**NWUX**). Morphological terminology follows Yeh and Lu (2017) and Nguyen and Xu (2017). Nomenclature of mesopleural sulci and sutures is shown in Figure 1. Length of body is measured from anterior margin of the head to the apex of the second metasomal tergum; length of first metasomal tergum is measured from the posterior margin of the tendon to the apex of the tergum medially, its height is the maximum height in lateral view. Observations and descriptions were made with an Olympus SZX11 stereomicroscope and fluorescent lamps. Photographic images were made with a Keyence VHX-5000 digital microscope and Photoshop CS 6 was used to make the plates.

Abbreviations: approx., approximately; id., idem; F, antennal flagellomere; S, metasomal sternum; T, metasomal tergum; ecc, epicnemial carina; eps, epipleural sulcus; ess, episternal sulcus; mps, mesopleural suture.

Table 1. List of *Zethus* spp. recorded from Oriental and Palaearctic fauna.

Oriental species	Distribution
Zethus albopilosus Giordani Soika, 1995	India
Zethus angulatus Nguyen & Carpenter, 2016	Vietnam
Zethus bakeri Giordani Soika, 1995	Singapore
Zethus celebensis Giordani Soika, 1960	Indonesia
Zethus ceylonicus de Saussure, 1867	India, Sri Lanka
Zethus dolosus Bingham, 1897	China (Guangdong), Bhutan, India, Myanmar, Thailand, Vietnam
Zethus fulgens Gusenleitner, 2007	Malaysia
Zethus improcerus Giordani Soika, 1995	Malaysia
Zethus indicus Giordani Soika, 1960	India (Sikkim)
Zethus luzonensis Giordani Soika, 1941	Philippines
Zethus malabaricus Giordani Soika, 1995	India
Zethus malayanus Gusenleitner, 2010	China (Guangdong), Malaysia, Vietnam

Oriental species	Distribution
Zethus mandibularis Giordani Soika, 1995	Indonesia
Zethus nanlingensis Nguyen & Xu, 2017	China (Guangdong)
Zethus nigerrimus Gusenleitner, 2001	China (Jiangxi), Vietnam, Laos, Malaysia
Zethus planiclypeus Gusenleitner, 1988	Thailand
Zethus propodeus Nguyen & Carpenter, 2016	Vietnam
Zethus puehringeri Gusenleitner & Gusenleitner, 2013	Laos
Zethus quadridentata Cameron, 1902	Borneo
Zethus soikai Selis, 2017	Philippines
Zethus tansoneus Nguyen & Carpenter, 2016	Vietnam
Zethus trimaculatus Cameron, 1904	India, Laos, Vietnam
Zethus tumidus Nguyen & Carpenter, 2016	Vietnam
Zethus varipunctatus Cameron, 1902	Malaysia
Zehtus velamellatus Tan, sp. n.	China (Zhejiang)
Palaearctic species	**Distribution**
Zethus asiaticus Gusenleitner, 2011	Kyrgyzstan
Zethus favillaceus Walker, 1871	Saudi Arabia, Djibouti, Sudan, Kenya, Tanzania, Burundi, Zimbabwe, South Africa

Key to species of the genus *Zethus* from China

1 First metasomal segment short and stout: 2.0–2.2× as long as its maximum width in dorsal view and approx. 2.5× as long as high in lateral view **2**

– First metasomal segment long and slender: 2.5–3.5× as long as its maximum width in dorsal view and 3.3–6.0× as long as high in lateral view **4**

2 Propodeal lamella almost invisible as the submarginal carina is not produced above propodeal valvulae; mesopleuron reticulate-rugose; first metasomal tergum punctate; clypeus of ♀ punctate-reticulate and depressed space between apical teeth without median ridge; second tergum with apical yellow band. China (Zhejiang) ..... ***Z. velamellatus*** **Tan, sp. n.**

– Propodeal lamella well-developed as the submarginal carina is produced into a distinct lamella above propodeal valvulae; mesopleuron sparsely punctate; first metasomal tergum reticulate-rugose; clypeus of ♀ punctate and depressed space between apical teeth with a median ridge; second tergum completely black **3**

3 Leg yellowish brown; clypeus of ♀ tri-dentate, clypeus of ♂ with apical notch 1/5 as wide as clypeus; mandible of ♂ with basal tooth forming a rectangular plate and separated from middle tooth by a broad notch. China (Taiwan) .... ***Z. taiwanus*** **Yeh & Lu, 2017**

– Leg black; clypeus of ♀ minutely bi-dentate, clypeus of ♂ with apical notch 1/6 as wide as clypeus; mandible of ♂ with two small basal teeth, similarly shaped and not separated by a broad notch. China (new record; Jiangxi); Laos; Malaysia; Vietnam ..... ***Z. nigerrimus*** **Gusenleitner, 2001**

4 First metasomal tergum long and slender, approx. 3.5× as long as wide, densely and coarsely punctate, and with median carina; propodeum shiny and with lateral carinae. China (Guangdong); Bhutan; India; Myanmar; Thailand; Vietnam ..... ***Z. dolosus* Bingham, 1897**

– First metasomal tergum relatively short and wider, approx. 2.5× as long as wide, finely punctate, and without median carina; propodeum dull and without lateral carinae **5**

5 First metasomal tergum in dorsal view nearly parallel-sided; second metasomal segment relatively long, 1.2× as long as wide; China (Guangdong); Malaysia; Vietnam ..... ***Z. malayanus* Gusenleitner, 2010**

– First metasomal tergum in dorsal view gradually widening from base to basal one-sixth of tergum, then gradually narrowed apically; second metasomal segment relatively short, 1.4× as long as wide; China (Guangdong) ..... ***Z. nanlingensis* Nguyen & Xu, 2017**

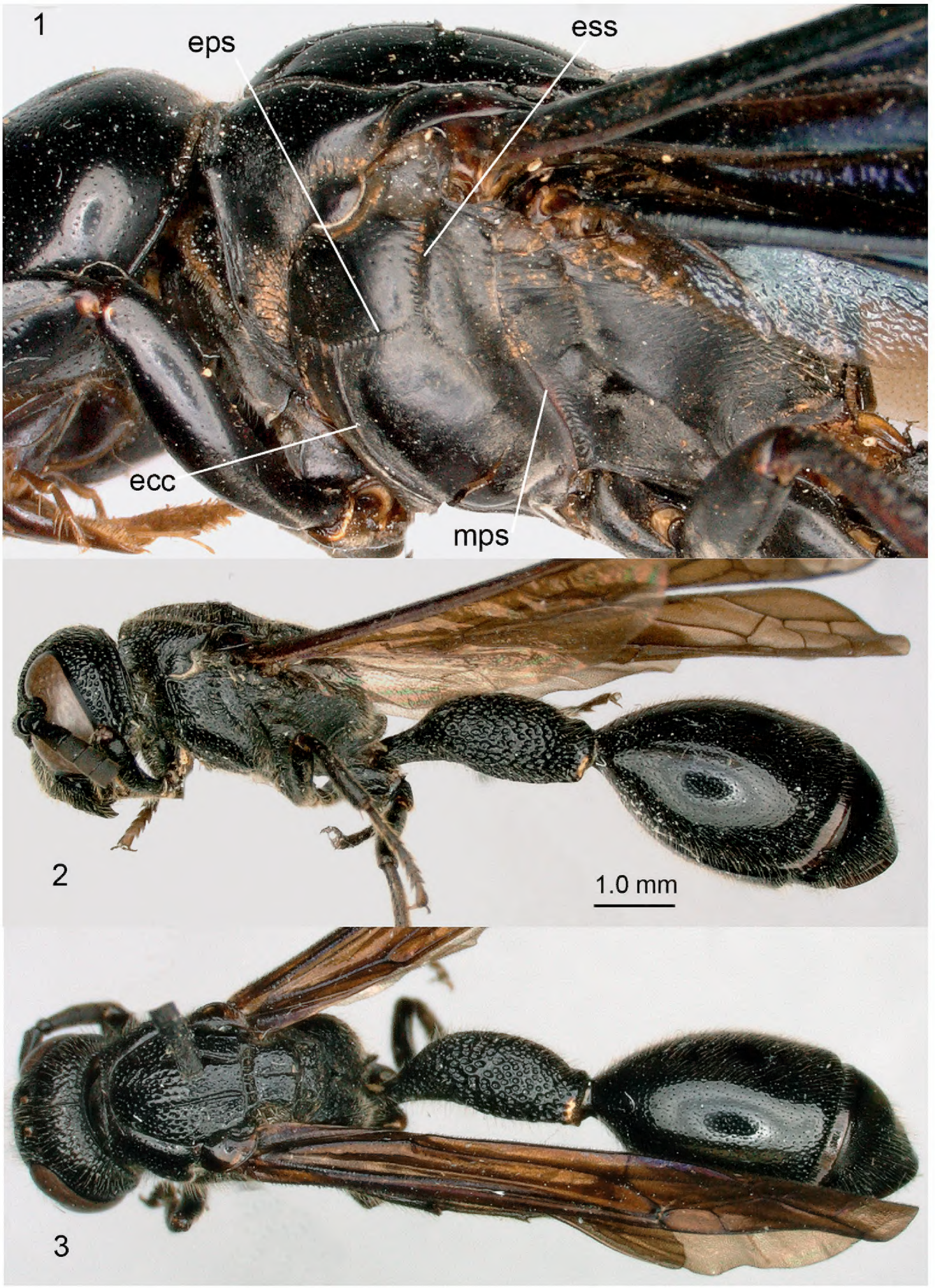
Taxonomy

***Zethus nigerrimus* Gusenleitner, 2001, rec. n.**
Figs 2–13

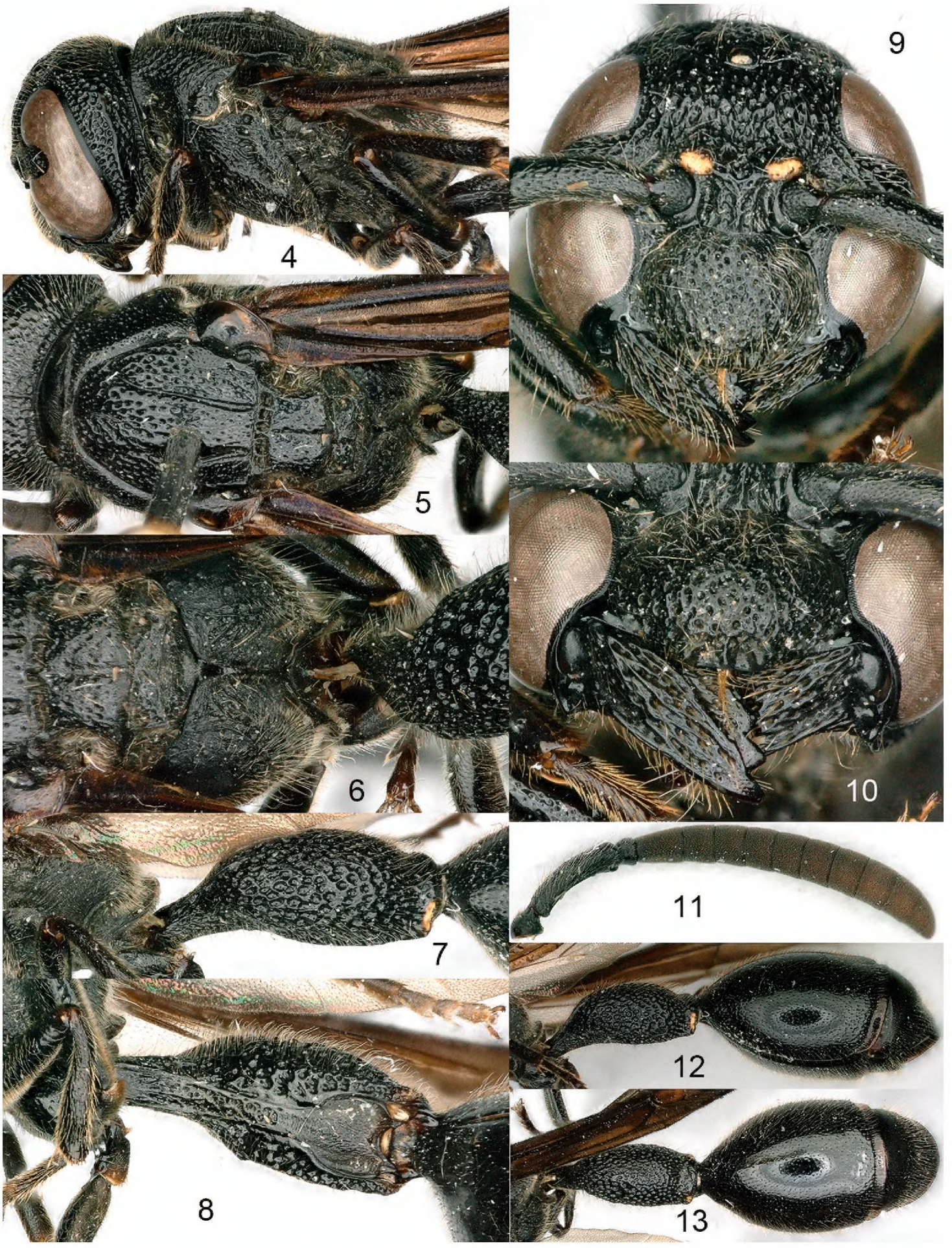
Zethus nigerrimus Gusenleitner, 2001: 659 (♀, N. Vietnam, Naturhistorisches Museum Wien); 2017: 101; 2012: 1050; Gusenleitner and Gusenleitner 2013: 138; Yeh and Lu 2017: 536.

Material examined. 1♀ (NWUX): "CHINA: Jiangxi, Fuzhou, Zixi, 7.vi.2010, N27.70°, E117.05°, Meijuan Lou".

Diagnosis. Body about 13.1 mm, almost entirely black, except a pair of yellow spots near dorso-inner margin of antennal sockets, and a pair of transverse yellow lateral spots on apical margin of TI (Figs 2, 3, 9). Clypeus of ♀ densely and shallowly foveate, minutely bi-dentate apically, depressed space between teeth with a median ridge (Fig. 10). Anterior half of mesoscutum strongly punctate-rugose, posterior half of mesoscutum, mesoscutellum and metanotum sparsely punctate with distance between punctures much longer than diameter of puncture. Epicnemial carina (Fig. 1, ecc) strong and raised, bordered posteriorly by narrow sulcus; episternal sulcus (Fig. 1, ess) wide, distinctly crenulate and depressed (Fig. 3), epipleural sulcus (Fig. 1 eps) indistinct; mesopleura (episternum) sparsely punctate below episternal and epipleural sulci, epicnemium and posterior part of episternum coriaceous (Fig. 3). Propodeum coriaceous with strong striae laterally; posterior depression very shallow, almost flat and finely transversely striate, submedian carina indiscernible; propodeal lamella well developed and protruding upward (Figs 6, 7). TI short, approx. 2.2× as long as wide in dorsal view and reticulate-rugose (Fig. 6); anterior half of SI reticulate-rugose and foveolate, posterior half densely transversely striate (Fig. 8). TII approx. 1.4× as long as wide in dorsal view, sparsely micro-punctate (Figs 12, 13); TII, TIII and SII with



Figures 1–3. 1 *Zethus coeruleopennis* (Fabricius), mesosoma, lateral aspect **2–3** *Z. nigerrimus* Gusenleitner, ♀ **2** Habitus, lateral aspect **3** id., dorsal aspect. Abbreviations: ecc = epicnemial carina; eps = epipleural sulcus; ess = episternal sulcus; mps = mesopleural suture.



Figures 4–13. *Zethus nigerrimus* Gusenleitner, ♀. **4** Head and mesosoma, lateral aspect **5** mesosoma dorsal aspect **6** propodeum, dorsal aspect **7** propodeum and TI, lateral aspect **8** SI, ventral aspect **9** head, anterior aspect **10** clypeus, anterior aspect **11** antenna **12** metasoma, lateral aspect **13** metasoma, dorsal aspect.

well-developed apical lamella, flat (about 0.25 mm, 0.4 mm and 0.17 mm long respectively); SII in lateral view smoothly curved from base to apical margin (Fig. 12).

Distribution. China (Jiangxi); Vietnam, Laos; Malaysia. It is a new record for China.

***Zethus velamellatus* Tan, sp. n.**
http://zoobank.org/DBA926D0-5F9C-44CC-B9C1-C39C4E8BA572
Figs 14–24

Material examined. Holotype, ♀ (NWUX): "CHINA: Zhejiang, Hangzhou, Lin'an, Qingliangfeng, Shunxi, N30.06° E118.94°, 23.viii.2013, Jiangli Tan".

Diagnosis. Clypeus of ♀ punctate-reticulate and depressed space between apical teeth without median ridge; mesopleuron reticulate-rugose; propodeal lamella almost invisible as the submarginal carina is not produced above propodeal valvulae; T1 unevenly punctate and approx. twice as long as its maximum width in dorsal view and approx. 2.4× as long as high in lateral view; SI densely striate and sparsely punctate; TI with apical yellow band.

Description. Length of body 13.0 mm; fore wing length 11 mm; width of mesonotum (including tegulae) 3.1 mm.

Head. Head transversely oblong, approx. 1.3× wider than high in anterior view (Fig. 20), about 2.2× wider than long in dorsal view, coarsely punctate-reticulate and with long setae. Temple contracted behind eyes, approx. 1.2× wider than eye in dorsal view. Occipital carina developed, with crenulae in front of it. Clypeus gently convex, slightly less than twice as wide as long, emarginated at basal margin; apex minutely bidentate, depressed space between both teeth without median ridge (Fig. 21); clypeus punctate-reticulate with dense yellowish brown long setae (more than three times ocellar diameter); width of apical depression about a quarter width of clypeus. Mandible with four teeth, coarsely punctate-rugose, third and fourth teeth truncated. Antennal scape punctate, 2.7× as long as its maximum width; FI 1.9× as long as its maximum width, FII as long as wide, FIII–IX wider than long, FX bullet-shaped, as long as its basal width (Fig. 22).

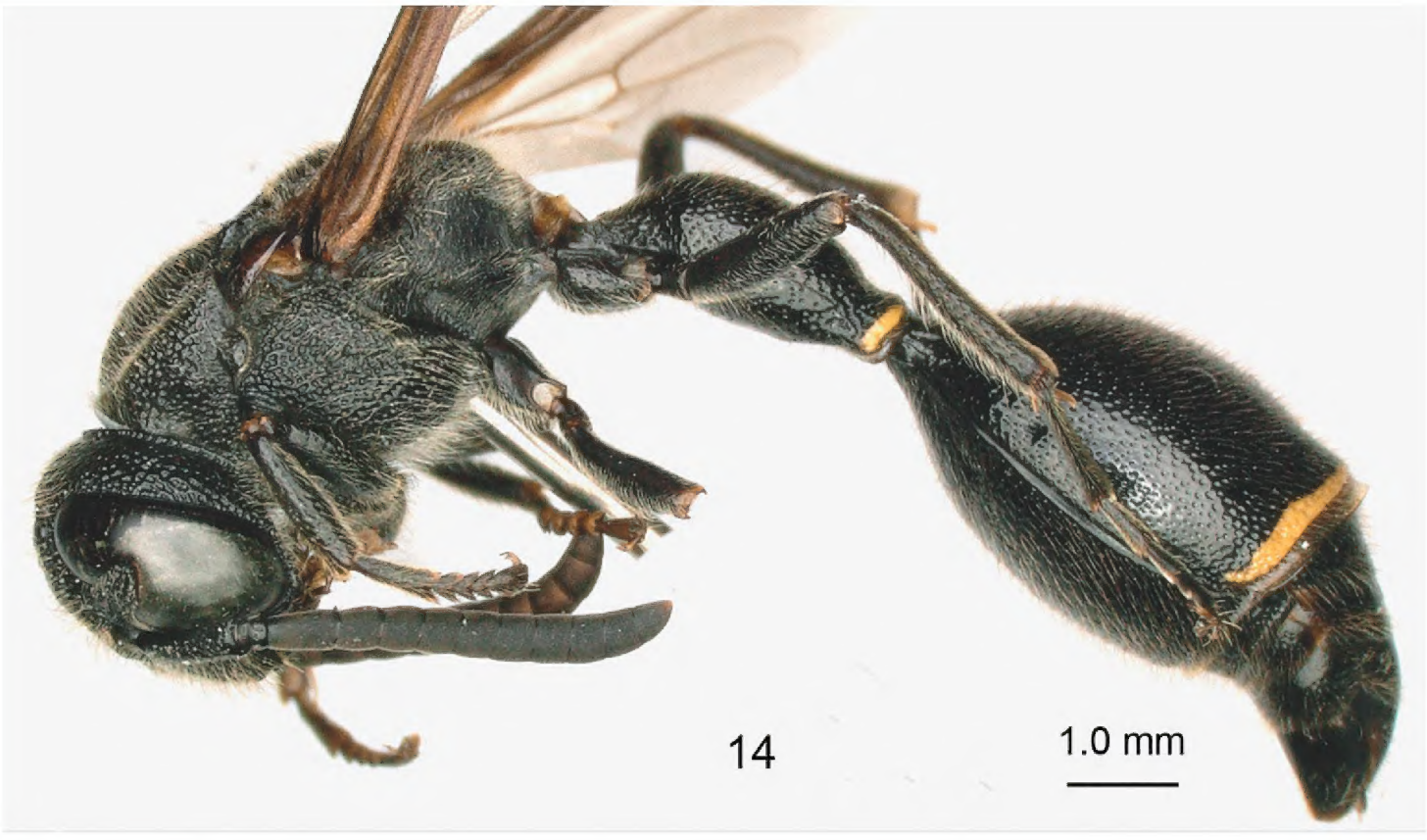
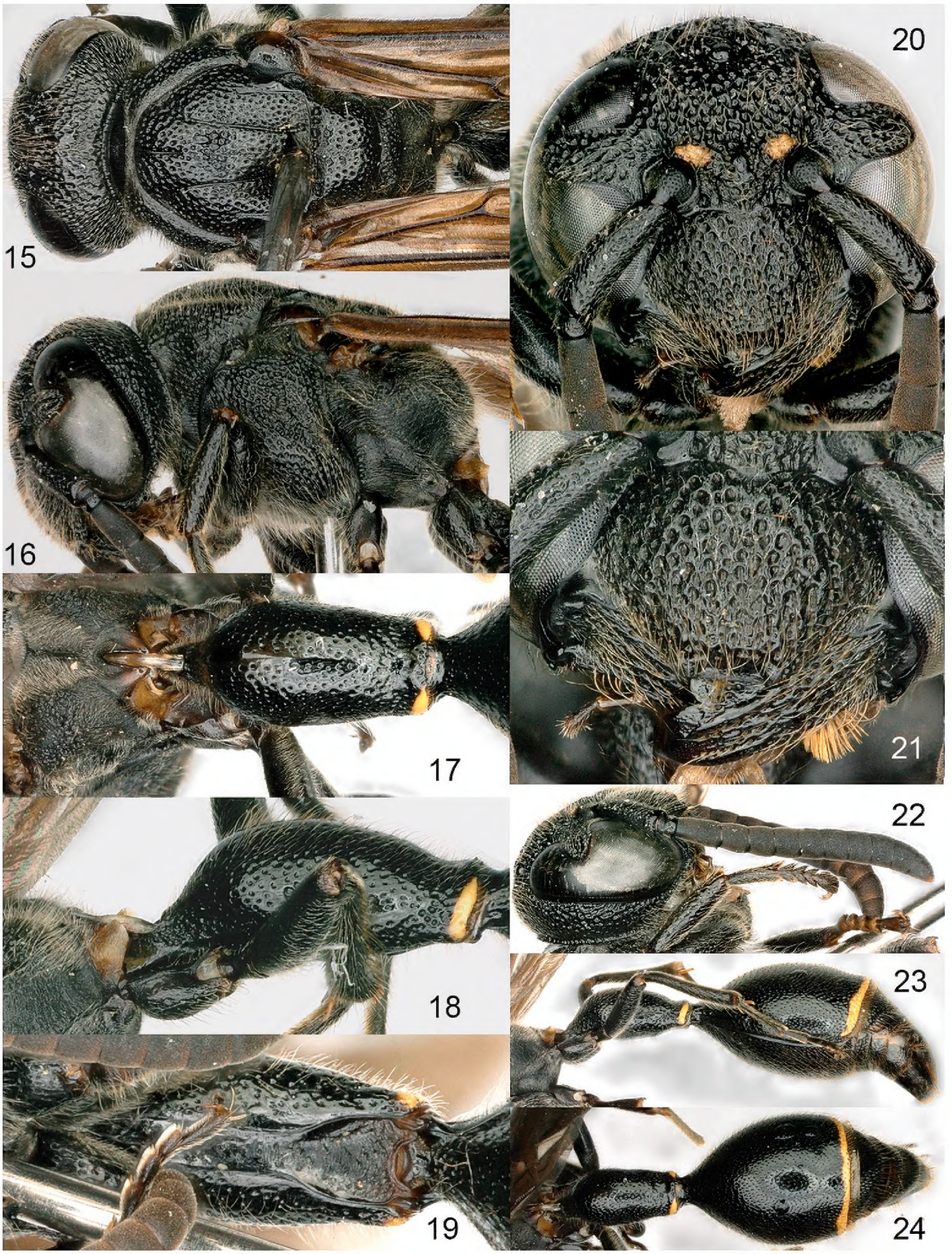


Figure 14. *Zethus velamellatus* Tan, sp. n., holotype, ♀, habitus, lateral aspect.



Figures 15–24. *Zethus velamellatus* Tan, sp. n., holotype, ♀. **15** Head and mesosoma, dorsal aspect **16** head and mesosoma, lateral aspect **17** propodeum and TI, dorsal aspect **18** propodeum and TI, lateral aspect **19** SI, ventral aspect **20** head, anterior aspect **21** clypeus, anterior aspect **22** antenna **23** metasoma, lateral aspect **24** metasoma, dorsal aspect.

Mesosoma. Pronotum reticulate-punctate dorsally with ventro-lateral area punctate-rugose (Fig. 15–16). Mesoscutum coarsely rugose-punctate to densely punctate (Fig. 15); mesoscutellum and metanotum coarsely punctate with distance between punctures less than diameter of puncture. Epicnemial carina distinct, bordered posteriorly by a narrow sulcus; episternal sulcus indistinctly developed as a crenulate depression, epipleural suture indistinct; mesopleuron (episternum) coarsely punctate-rugose (Fig. 16), below pleural and epipleural sulci densely punctate-rugose with epicnemium and posterior part of episternum coriaceous (Fig.16). Propodeum coriaceous-aciculate laterally and without lateral carina (Fig. 17), coriaceous-reticulate postero-laterally and oblique punctate-rugose along each side of median carina and with dense setae (Fig. 17); submarginal carina not produced into a lamella resulting in absence of propodeal lamella above propodeal valvula (Fig. 17).

Metasoma. TI short, about twice as long as wide in dorsal view, gradually widened from base to basal one third, then slightly narrowed toward apex, with maximum width 3.1× its basal width (Fig. 17); in lateral view smoothly curved between basal stem and apical part; strongly convex dorsally, about 2.4× as long as high (Fig. 18); TI unevenly punctate; SI densely striate and sparsely punctate (Fig. 19). TII sparsely punctate with rather short petiole basally, about 1.4× as long as wide in dorsal view (Figs 23, 24); SII in lateral view smoothly curved from base to apical margin (Fig. 23); TII and SII with raised apical lamella of approx. 0.2 mm and 0.1 mm long, respectively, apical lamella of TIII flat and approx. 0.25 mm long.

Colour (Figs 14–19). Body black, except a yellow spot near dorso-inner margin of antennal socket, a pair of transverse yellow lateral spots on apical margin of TI, TII with a narrow yellow subapical band and propodeal valvula yellowish brown. Wings yellowish brown tinged.

Remarks. *Zethus velamellatus* sp. n. fits well into the *trimaculatus*-group (Giordani Soika 1958, Yeh and Lu 2017) in sharing the main character of a short and stout first metasomal segment. The new species is easily to separate because of the missing submarginal lamella of the propodeum, the punctate sculpture of SI and smoothly curved profile of SII in lateral view.

Distribution. China (Zhejiang).

Etymology. This species is named "velamellatus ("ve" is Latin for "without") because the propodeal lamella is invisible in this species.

Discussion of Oriental and Palaearctic distribution of *Zethus* Fabricius

Zethus Fabricius, 1804, is the most speciose genus of the Vespidae. It consists of 272 valid species, mainly occurring in the pantropical area with most species in the Neotropical region (230 species); the numbers are much lower for the other regions Afrotropical (15), Oriental (26), and Palaearctic (2) (Giordani Soika 1940, Bohart and Stange 1965, Gusenleitner 2011, Carpenter et al. 2010, Carpenter and Madl 2011,

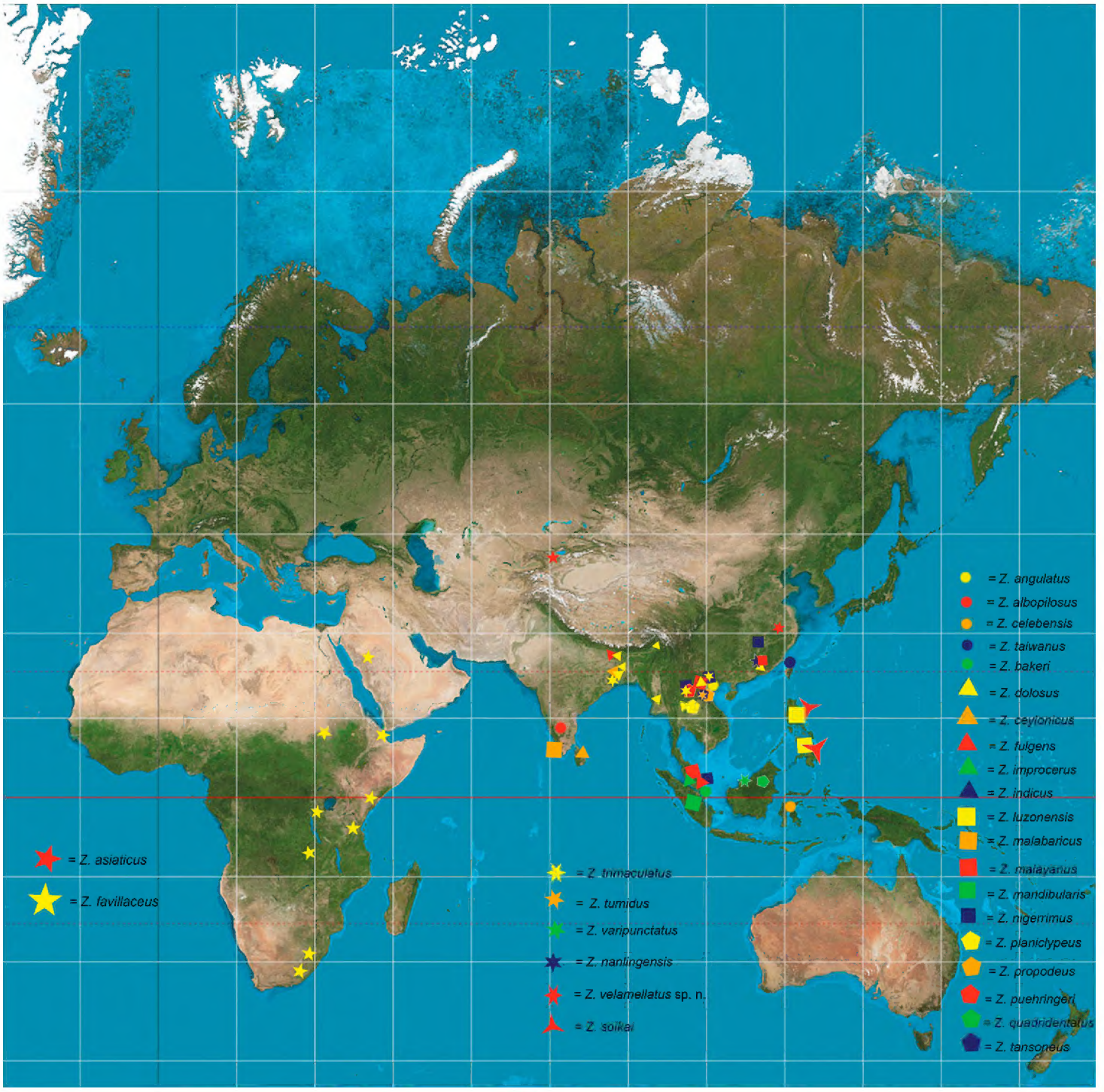


Figure 25. Zoogeographical map illustrating *Zethus* spp. recorded from Oriental and Palaearctic regions; *Z. favillaceus* is included as borderline species. Map from: http://blogs.discovermagazine.com.

Nugroho et al. 2012, Nidup et al. 2016, Nguyen and Carpenter 2016, Carpenter, unpublished). In addition, Bohart and Stange (1965) reported one undescribed species from Australia. Compared with its Oriental congeners, *Z. velamellatus* is the most northern (30°N) species known so far. The type locality (Fig. 25) lies within the boundaries of the Palaearctic-Oriental transitional zone as defined for mammals (between 33°N and 28°N; Hoffmann 2001).

A widespread but sporadic distribution may suggest a relict group (Tan et al. 2010). Hermes et al. (2014) recovered Zethini sensu lato as the sister-lineage to the remaining Eumeninae. The fossil and phylogeny of the genus is still unclear (Bohart and Stange 1965). The genus has been divided into four subgenera: *Zethoides* Fox and *Zethusculus* de Saussure, are restricted to the Western Hemisphere, *Madecazethus* Giordani Soika is endemic in Madagascar, but *Zethus* Fabricius s. str. is pantropical (Bohart and Stange

1965, Giordani Soika 1979). This distribution pattern fits well with "classic Indian Ocean (Gondwanic)" pattern (de Jong and van Achterberg 2007; especially the example of the genus *Celaenorrhinus* (Lepidoptera)). The research on Cretaceous fossil Vespidae reveals two basal groups (Priorvespinae and Euparagiinae) indicating that the time of subfamily-level division of Vespidae could be traced back to about 120–65 Ma (Carpenter and Rasnitsyn 1990). The connection between Africa and South America was severed during Late Cretaceous, at least 80 Ma (Hallam 1994). The minimum age of the Eumeninae is estimated to be approx. 90 Ma (Perrard et al. 2017) and the origin of the genus *Zethus* could be estimated between 90–80 Ma, allowing for the Gondwanic distribution pattern.

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